

# Byzantium in Bing: Live Virtual Acoustics Employing Free Software

Fernando Lopez-Lezcano, Travis Skare,  
Michael J. Wilson, Jonathan S. Abel



the goal was simple:

# how to fit this:



Hagia Sophia, Istanbul, Turkey



# into this:



Bing Concert Hall, Stanford, California, USA



or expand this:





into this:



# and put singers inside!

in real-time, of course

in concert, not a demo

bonus points for using free software...

more points for using ambisonics (it is a good excuse)...

ultimate prize if the whole thing does not crash and burn

# acoustic spaces

- crucial to the act of experiencing music
- singing tied to the space in which it occurs
- reverberation affects tempo
- room modes affect pitch
- music written for a particular space works best in that space

# hagia sophia

- world heritage site
- 360 -> 1204: orthodox cathedral
- 1204 -> 1261: catholic cathedral
- 1261 -> 1453: orthodox cathedral
- 1453 -> 1931: mosque
- 1931: secularized... (it is now a museum)
- 55.6 m dome (182 ft), ~ 31 m diameter (~102 ft)
- more than 10 seconds of reverberation time  
(a choir performance there would be impossible today)



# bing concert hall

- 2013: inauguration...
- 842 seats, terraced design
- ceiling 47 feet above the stage
- 680,000 cubic feet volume
- around 2.5 seconds reverberation time (~2 with all “variable acoustics” surfaces deployed)

# previous work

- icons of sound project (abel, pentcheva, kolar & others)
- recording of ballon pops in hagia sophia, reconstruction of impulse responses
- dry recording of singers (cappella romana) with headphone provided virtual environment (CCRMA Stage)
- studio mix of dry signals with artificially reconstructed environment (Listening Room 22.4 system using Ambisonics – 32 convolutions total)

# transitions 2011

- outdoor summer concert
- 16.4 system (2 rings of 8)
- playback of the prokeimenon mix using a mix of 2D and 3D Ambisonics decoders
- very successful given the limitations

# bing?

- the possibility of a concert in the inaugural season of the bing concert hall arises...



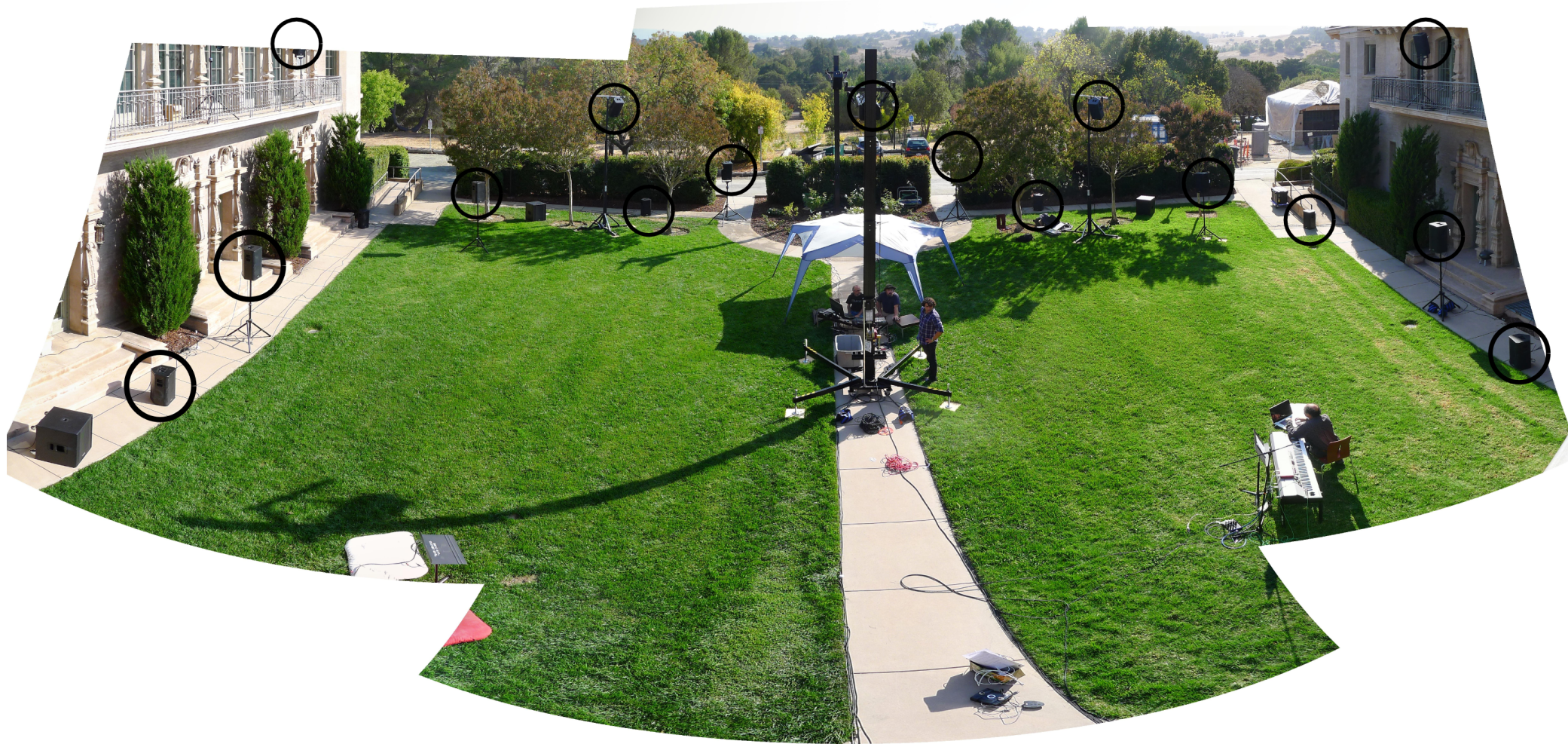
Bing Concert Hall, November 2011

# transitions 2012

- outdoor summer concert
- 24.6 system (full “3D”)
- real-time Hagia Sophia recreation
  - two singers
  - jconvolver plus ardour for mixing
- validated real-time processing of live sound

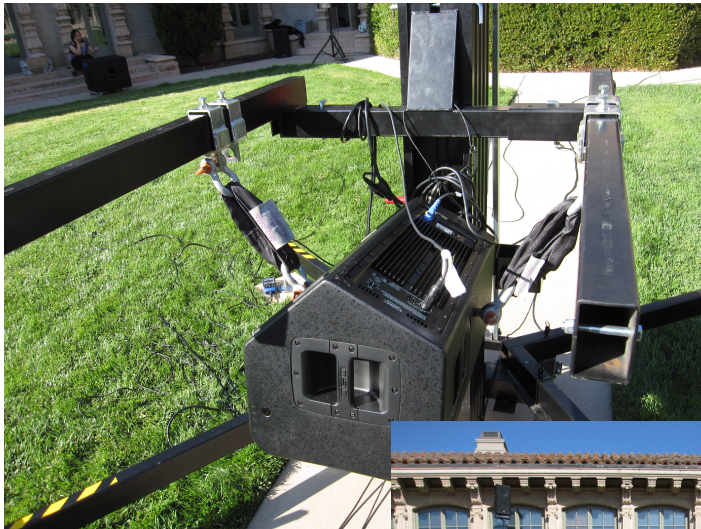


# transitions 2012





# transitions 2012





# transitions 2012





# back to: bing concert hall

- terraced design
- not designed for surround but for unamplified music performances
- but design incorporated “plumbling” for multichannel work
- and also enough rigging points through the “cloud” ceiling

# sound system

- 24.6 system based on QSC speakers
- HPR122i + HPR181 subs
- HPRs no longer in production – could not find alternatives at that price point and performance
- NetworkSound AudioStreamer box as D/A with the jack-mamba jack client as driver (32 i/o channels – see lac2012 paper)

# sound system

- all software is running on one of our fanless workstations (see LAC2009 paper)
- usually remoted through ethernet cables
- ardour + supercollider + ambdec + jack-mamba + misc
  - supercollider: LR4 sub crossovers and delay and level compensation
- netjack for other computers or laptops

# rigging



2 day technical “rehearsal”, December 2012 (proof of concept)

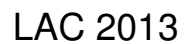


# rigging



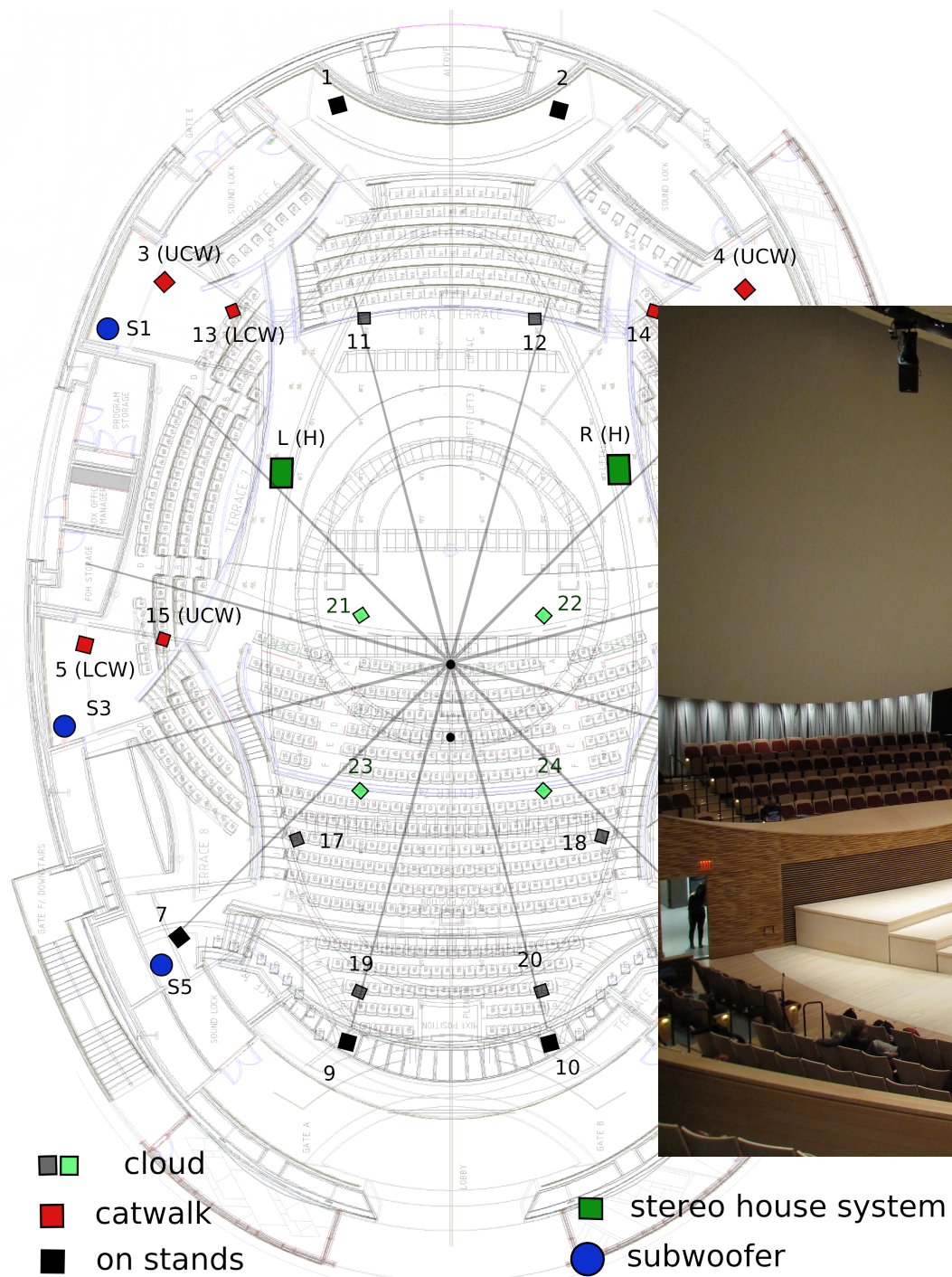


Fernando Lopez-Lezcano, CCRMA





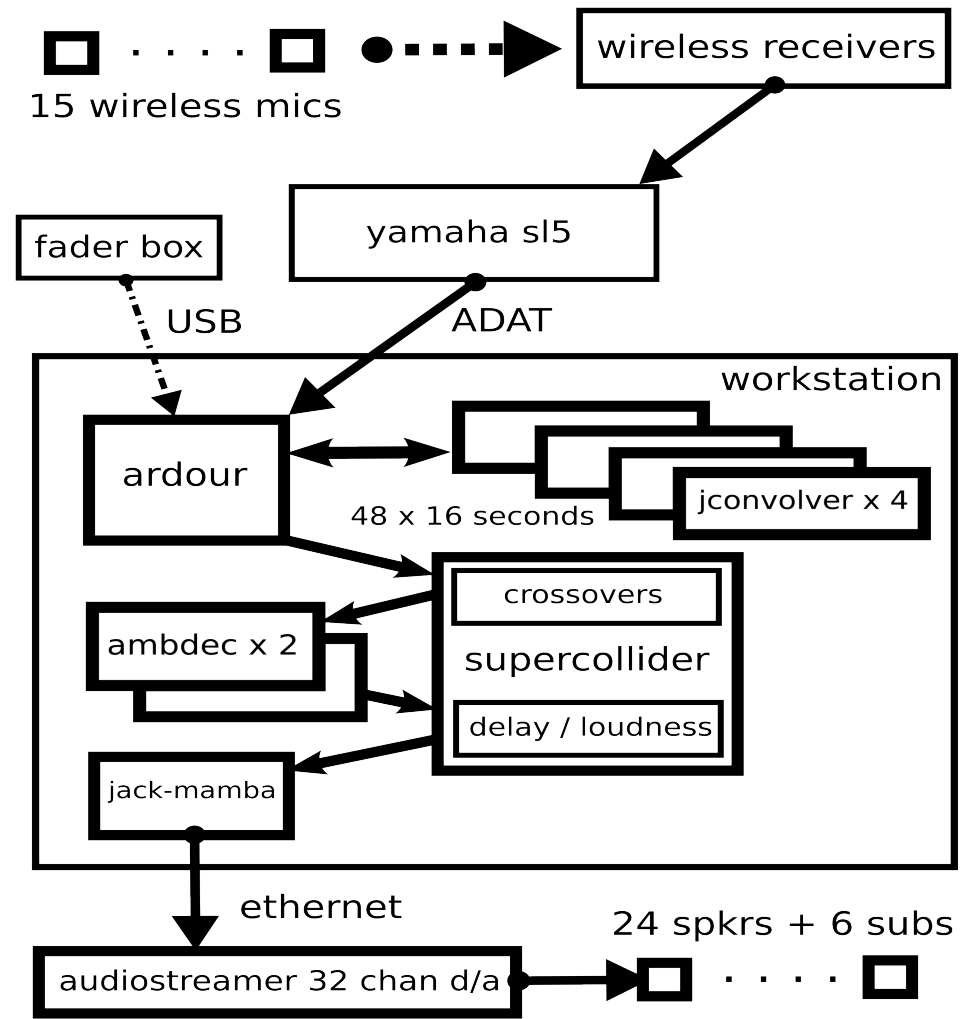
# locations



cappella romana rehearsing

# signal routing

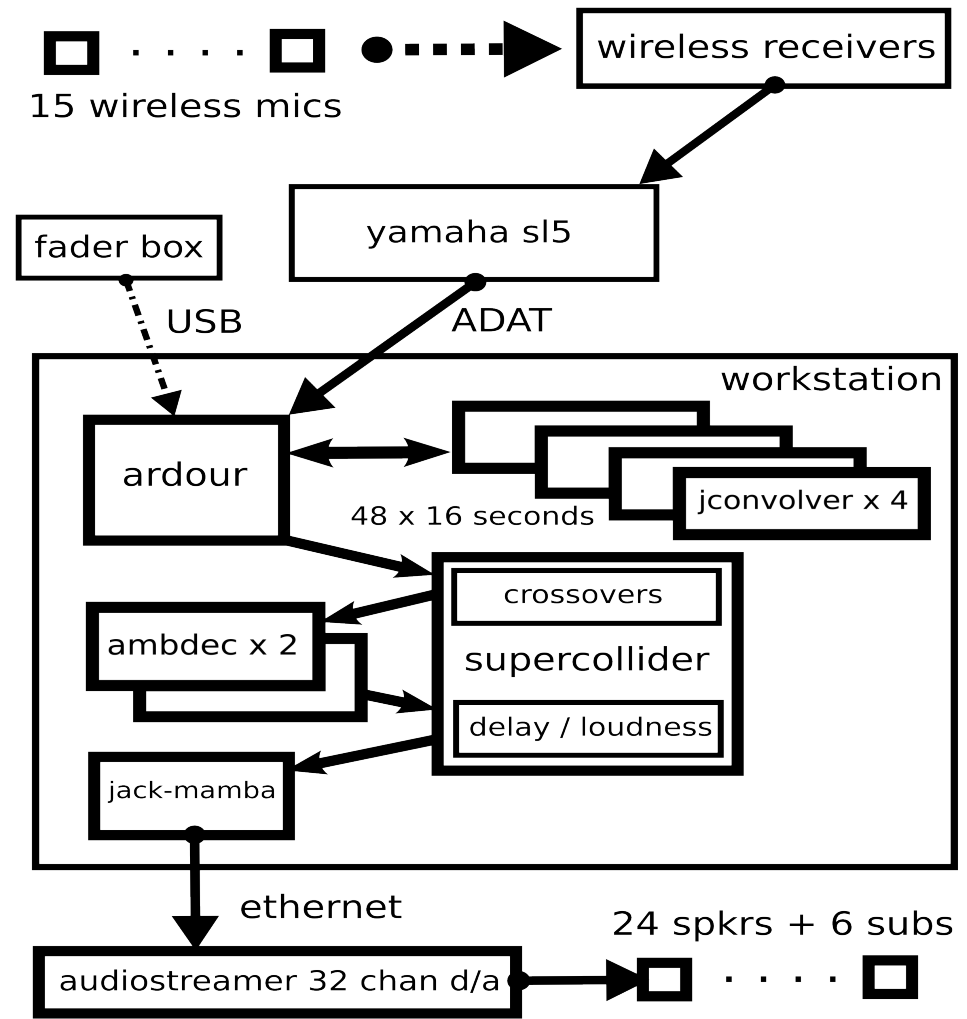
- wireless mics  
(countryman b6)
- house mixer
- adat -> computer  
(rme raydat pcie)
- <some processing>
- ethernet -> D/A
- D/A -> speakers





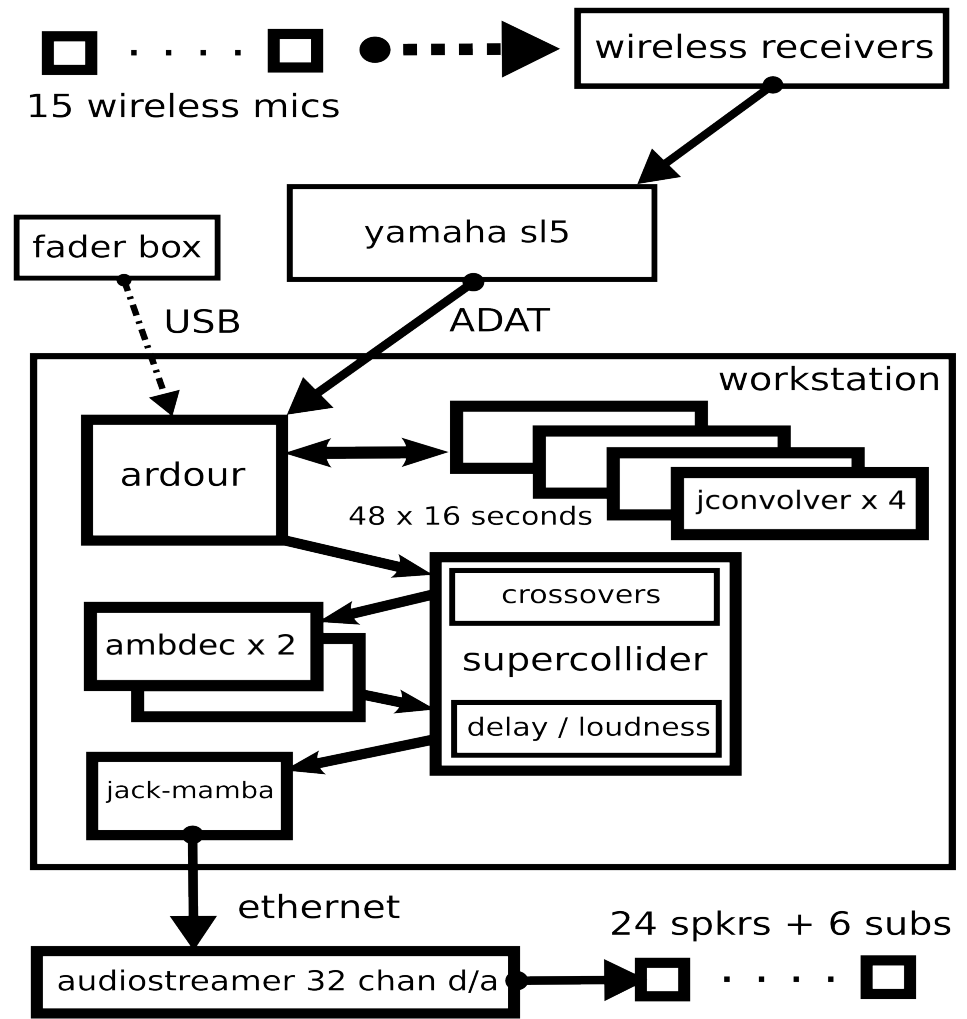
# signal processing

- jack: 256x2, 48Khz
- 4 x jconvolver
- supercollider
- 2 x ambdec  
(aaron heller coeffs)
- jack-mamba



# control

- bcf2000 usb fader box, in ardour:
  - master
  - hagia
  - dry



# the concert



## CAPPELLA ROMANA

"FROM CONSTANTINOPLE TO CALIFORNIA"

**Friday, February 1, 2013 | 8:00 pm**

**Bing Concert Hall**

\$34.00 (Adult) | \$10.00 (Stanford Student)

\$30.60 (Other Student)

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[Dining Options »](#)

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[Parking & Directions »](#)

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[Seating Chart »](#)

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[Program Notes »](#)

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[Additional Information »](#)

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## Links

[Cappella Romana website](#)

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## Video



# cappella romana

- Cappella Romana is a vocal chamber ensemble dedicated to combining passion with scholarship in its exploration of the musical traditions of the Christian East and West, with emphasis on early and contemporary music.

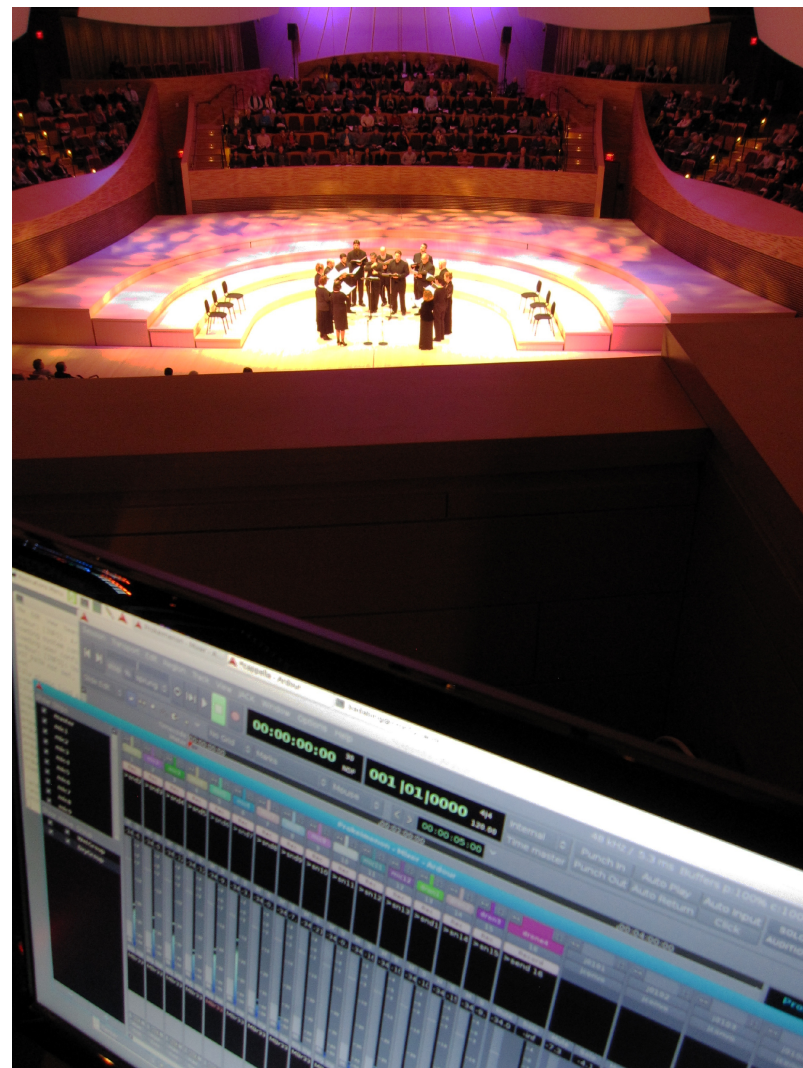


# the concert





# the concert



# prokeimenon



# after the concert

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I'm not kidding...

# thanks to...

so many...

chris chafe, bissera pentcheva, jenny billfield, aaron heller, carr wilkerson, sasha leitman, jay kadis, alexander lingas, mark powell and cappella romana, fr. salmas and the byzantine chanters from the church of the holy cross in belmot, ca;

Stanford Presidential Fund for Innovation in the Humanities, the Stanford Arts Initiative, Countryman Associates for donating the B2D Directional Lavalier microphones & Christine and Reece Duca, whose generous support made possible the concert and recording sessions

# questions?